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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Automated Process Application in Steel Fabrication and Subassembly Facilities; Project Summary

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

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NSRP 1-96-6

AUTOMATED PROCESS APPLICATION IN STEEL FABRICATION AND SUBASSEMBLY FACILITIES PROJECT SUMMARY

A PROJECT OF

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

FOR

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

SHIP PRODUCTION COMMITTEE

SP-1 FACILITIES AND ENVIRONMENTAL EFFECTS PANEL

BY

NATIONAL STEEL AND SHIPBUILDING CO.

SAN DIEGO, CA

NOVEMBER 1999

Final Report

NSRP 1-96-6

Automated Process Application in Steel Fabrication and Subassembly Facilities

Project Summary

Contract Number N00167-94-H-0038

A project of

The National Shipbuilding Research Program

for

The Society of Naval Architects and Marine Engineers

Ship Production Committee

SP-1 Facilities and Environmental Effects Panel

by
National Steel and Shipbuilding Co.
San Diego, CA

Project Manager:
John Horvath

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November 1999

1.0 Introduction

The objective of NSRP Project 1-96-6 was to develop a methodology to identify specific processes within Steel Fabrication and Subassembly that were good candidates for automation, and to determine the degree and mix of automation which would have the best overall effect on the defined areas. Because of the large scope of the project, computer simulation was used to model the focus areas. Computer simulation lends itself well to investigations such as this because of software's capability to:

- Determine the effects of randomness and variability in the processes
- Model large systems with many variables
- Determine effects over long periods of time
- Determine effects of costly changes before investing money and resources
- Quickly produce results for comparisons of system changes
- Present concepts visually as an aid in explaining them

Models were created that were representative of National Steel and Shipbuilding Company's (NASSCO) current Steel Fabrication and Subassembly processes. These "As-Is" models were then analyzed for bottlenecks and constraints that could be overcome through the use of automation. Once the constraints were identified and suitable automation alternatives were purposed, "To-Be" models were created incorporating the automation. The results of the "As-Is" and "To-Be" models were used in order to compare the performance of the two systems, and as a basis for a Return on Investment (ROI) calculation.

2.0 Phases of the NSRP Project

The project was carried out in two Phases. Phase I (process analysis) tasks included:

- Choosing the simulation software and consultant
- Training the project team in the use of the simulation software
- Defining and understanding NASSCO's existing shipyard production processes in Steel Fabrication and Subassembly
- Modeling the existing processes
- Analyzing the model to identify bottlenecks and constraints in the system

The Phase I Final Report completed in July 1998 covers these topics in great detail including the project team's experience and results of the models.

Phase II (process comparison) tasks included:

- Identifying automation solutions to constraints in the system
- Benchmarking the use of the automation solutions in "World Class" yards
- Modeling the automation solutions
- Comparing the results of the "To-Be" models to the "As-Is" models and calculating a ROI

The Phase II Final Report completed in May of 1999 also covers these topics in great detail including the project team's experience and results of the ROI calculations.

3.0 Modeling Methodology

The methodology recommended by most texts for conducting a simulation project is very straightforward:

- Plan the study
- Define the system boundary

- Build the models
- Run the experiments
- Analyze the output
- Report the results

Planning the study is the most important task. Due to the nature of simulation modeling, it is very easy to get sidetracked or overrun budgets due to excessive detail and unclear model objectives. A proper plan is necessary to avoid this from happening. A simulation specification was created by the project team to act as the guiding document for this project (The simulation specification is included in the Phase I Final Report.). A simulation specification is a detailed document that:

- Details the objectives of the study
- Outlines information used in the study
- Lists the requirements for the form and functionality of the model
- Defines how the model will be verified and validated
- Sets the schedule for the project
- Details the format of the model output and what data it should contain

The specification was also used to solicit bids for the modeling work. Kiran Consulting Group in San Diego was selected to build the models for this project. In addition to their expertise in using the selected software (ProModel), their locally based operations made it easy to set up face-to-face meetings necessary to discuss and view the process areas and models.

Looking at the simulation project plan from the standpoint of introducing automation in Steel Fabrication and Subassembly the methodology for conducting this project is shown in Figure 1.

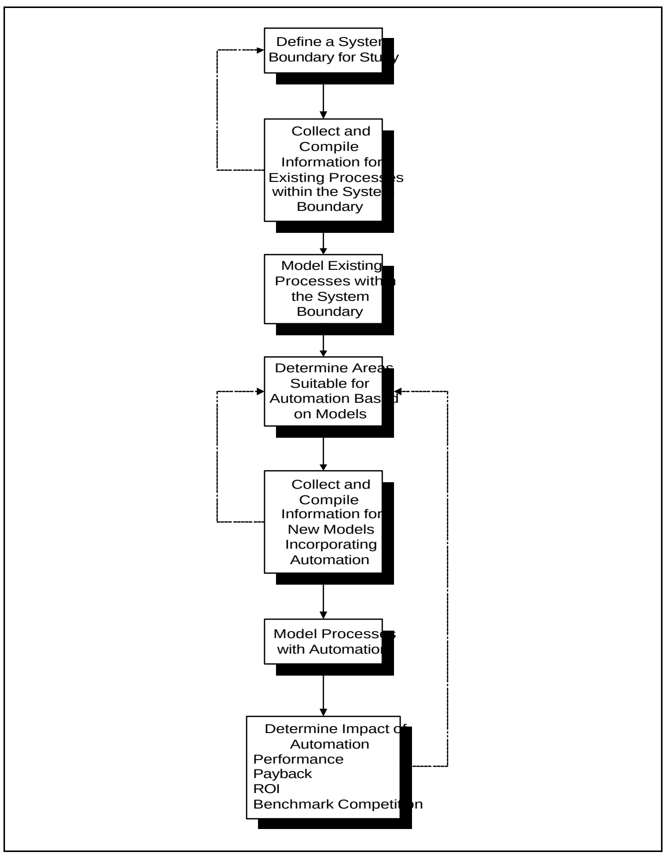

Figure 1

There are three points in the model where information in a later step might cause a project team to revisit a previous step to make changes concerning assumptions or the way the modeling is done. This might force another iteration of the process. For example, once suitable areas for automation had been proposed, detailed information collected on the automation solutions may indicate that the planned automation may not properly perform in the environment where the production is to take place. In this case, new automation scenarios may have to be defined or the decision not employ automation made.

4.0 Models

The system boundary for the study in this project is shown in Figure 2. The areas in the boundary make up NASSCO's Steel Fabrication and Subassembly operations. Figure 3 shows the geographic locations of these areas within the yard.

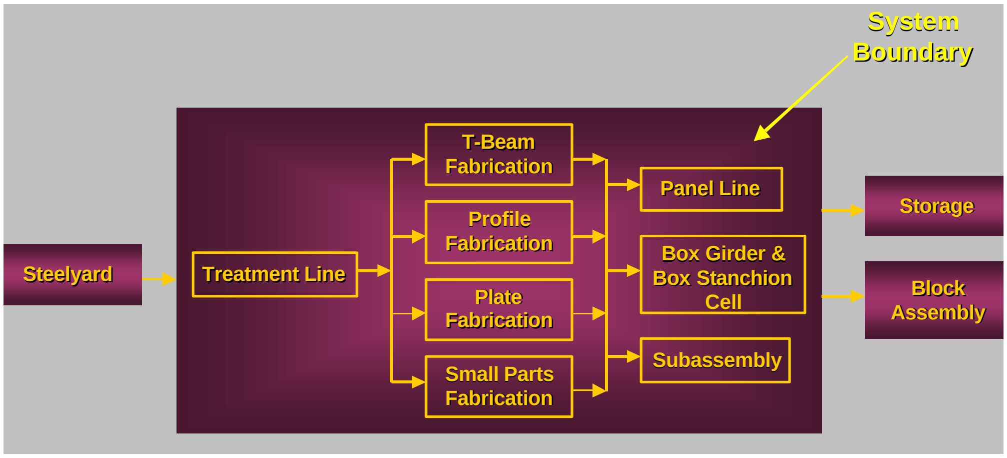

Figure 2

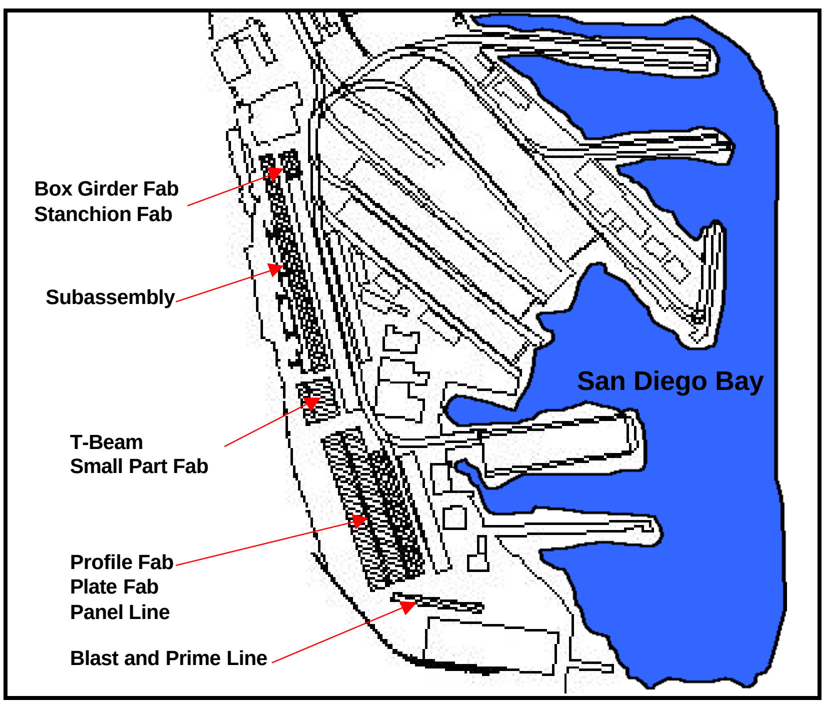

Figure 3

One model was created for each individual production process area in the system boundary. This allowed the project team to model each area in greater detail than if all of the areas were included in one large model. Determining the effects that each area has on the other areas in the system, however, is an important part of the investigation. In order to accomplish this, the project team setup the models to output key process information to a higher-level model of the overall Steel Fabrication and Subassembly area. The Overall Model allowed the team to not only observe the effect of adding automation to the individual process area, but how the individual process area affected the rest of the system.

Flowcharts similar to the one shown in Figure 4 for the Profile Fabrication Area were the primary tool used to define the existing production processes. The flowcharts greatly simplified the explanation of the process to the modelers at Kiran Consulting Group who did not have detailed knowledge of the Fabrication and Subassembly processes.

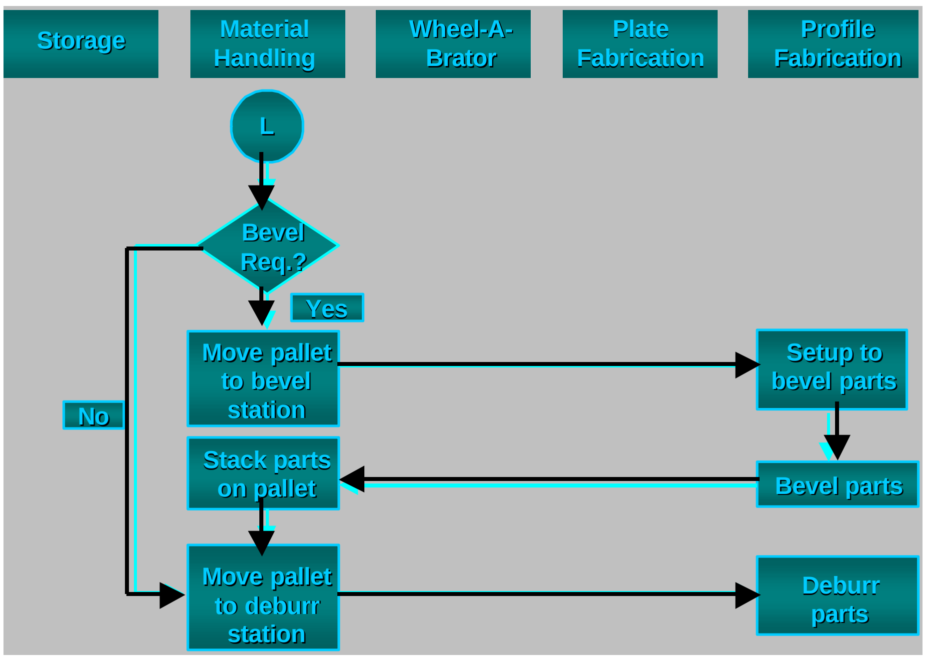

Figure 4

5.0 Results

Several experiments were run with the models for both the "As-Is" and " To-Be" conditions. The type of experiment was dependent upon the type of information that was used to create the model and the scenarios that were looked at to determine the best Return on Investment. For example, several iterations of the "As-Is" Profile Fabrication model were run in three separate stages to develop the comparison data for the "To-Be" model.

Because the information gathered for the Profile Fabrication Area was collected for a particular time in history, it was used to setup a "Baseline" model for the area. This particular snapshot in time, however, was not necessarily the best point to use as a comparison to a "To-Be" process. The resource and throughput information was collected during a low point in the build cycle of the ship, therefore, throughput was not at a maximum. In order to get the best utilization and throughput, that was still representative of the current process, the manning and material availability in the computer model was increased to its maximum to develop a "High Output" condition. From the "High Output" condition the manning was reduced to be more representative of manpower density restrictions currently in effect in the area. The resource utilization was being monitored during this time to also ensure that the manpower was

being utilized as efficiently as possible. The outcome was the “Most Likely Operating” condition, which was used as the comparison point for the “To-Be” model.

Analysis of the model output for the “Most Likely Operating” condition indicated that the Profile Fabrication Area was a good candidate for automation due to:

- Overutilization of some resources
- Raw stock material waiting for resources to begin processing
- Inability to expand work area to accommodate more resources
- Repetition of processes

A robotic profile cutting system was recommended for this area based on the following advantages observed in other yards employing the system:

- Utilization of the robot was better than the utilization of the resources in the manual process
- Throughput was equal or better than the manual process
- Automated production was done in equal or less work area
- Manpower levels remain stable regardless of workload

Benchmarking trips were made to yards in Europe that employed robotic cutting systems. The information gathered was used to create a “To-Be” model of the Profile Fabrication Area incorporating automation in order to verify that the same results observed in the yards in Europe could also be achieved at NASSCO. In fact, these results were confirmed in the “To-Be” model. The results were:

- Better utilization of the locations and resources was achieved in the automated cutting process.
- Throughput was increased 10% in the automated cutting process.
- Manning was reduced 82% (from 17 to 3) in the automated cutting process.
- The automated cutting area utilizes the same production area as the manual area.

A payback calculation was done using the savings in labor to determine the time for recovering the cost of implementing the robotic cutting system in the Profile Fabrication Area. The calculation is shown in Figure 5.

	"As-Is"	"To-Be"
Simulation Run Time (hrs)	840	840
Total Raw Stocks Processed	6791	7498
Total Parts Produced	22567	24650
Total Manning	17	3
Resouce Cost ($/hr)	32	32
Hours Per Year	2000	2000
Labor Cost per Year ($)	1088000	192000
Savings Over "As-Is" ($/year)	n/a	896000
Profile Fabrication Robot Cost ($)	n/a	2000000
Payback (years)	**n/a**	**2.23**

Figure 5

The calculation indicates that the payback period for the cutting system would be 2.23 years, which is reasonable for this type of automation application.

It is interesting to note that although this investigation shows a significant savings in labor costs, the leading yards in the application of shipbuilding automation consider four other factors as the primary drivers for the use of automation rather than direct labor savings:

- Reduction of construction span time
- Increase in production predictability and a decrease process variation
- Enforcement of discipline and accuracy control of non-automated operations
- Transfer of critical labor skills to technological capabilities

These savings are difficult to quantify using the simulation models, but do contribute significantly to overall construction cost savings.

6.0 Overall Model

In addition to the area models, such as the Profile Fabrication Area model, a high-level Overall Model was created to:

- Prevent sub-optimization of the Fabrication and Subassembly areas
- Understand utilization of and potential problems for shared resources between areas
- Determine the effect of changes on overall area production goals

Information from the individual models is loaded into the Overall Model through the Visual Basic front-end interface shown in Figure 6. The front-end interface gave the project team the capability to switch between possible automation scenarios in the model in order to balance the overall system.

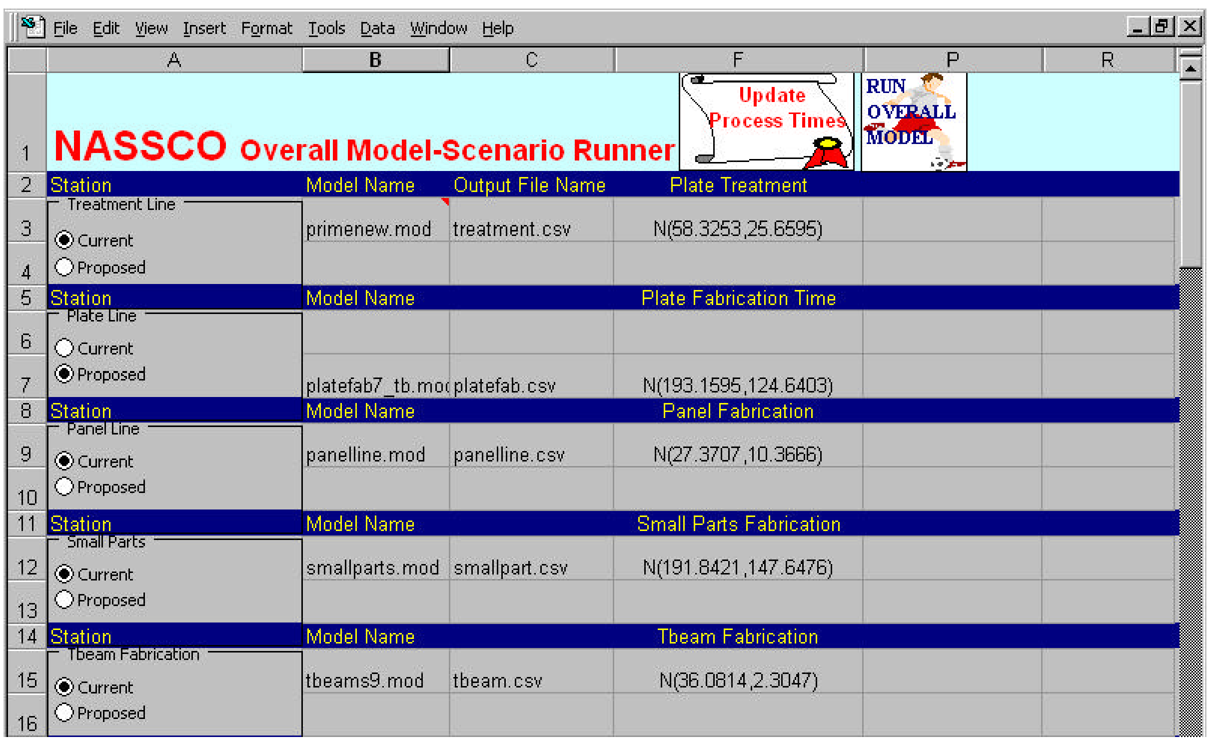

Figure 6

Start dates for all of the material to be processed in the area were also loaded into the model through the front-end interface. The data table for the date information is shown in Figure 7 below.

	A	B	C	D	E	F	G	H	I
1	Block #	Description	Soc1 Start	Days	Plates	Flatbar	Profiles	Soc2 Starts	Days
2	0028	SKEG	4-Jan-96		28	0	24	19-Jan-96	15
3	0029	ENGINE ROOM INNERBOTTO	15-Jan-96	11	33	0	30	30-Jan-96	26
4	0001	ENGINE ROOM INNERBOTTOM	12-Feb-96	39	115	49	38	27-Feb-96	54
5	0002	ENGINE ROOM INNERBOTTOM	20-Feb-96	47	84	27	43	6-Mar-96	62
6	0030	ENGINE ROOM INNERBOTTOM	27-Feb-96	54	36	15	29	13-Mar-96	69
7	0035	34'-7" FLAT WITH SIDE SHELL	11-Mar-96	67	42	30	45	26-Mar-96	82
8	0036	34'-7" FLAT WITH SIDE SHELL	29-Mar-96	85	15	9	18	15-Apr-96	102
9	0004	INNERBOTTOM "G" DECK	17-Apr-96	104	33	22	72	2-May-96	119
10	0181	45'-10" FLAT WITH SHELL PORT	25-Apr-96	112	38	23	58	9-May-96	126

Calculate Days

Figure 7

The material is released on its respective Stage of Construction (SOC) date, and the key process information from the individual models is used to calculate the duration of the final product through the shop or subassembly area. All process areas are running simultaneously in the Overall Model shown in Figure 8. Shared resources such as forklifts and log carriers transport the products between areas.

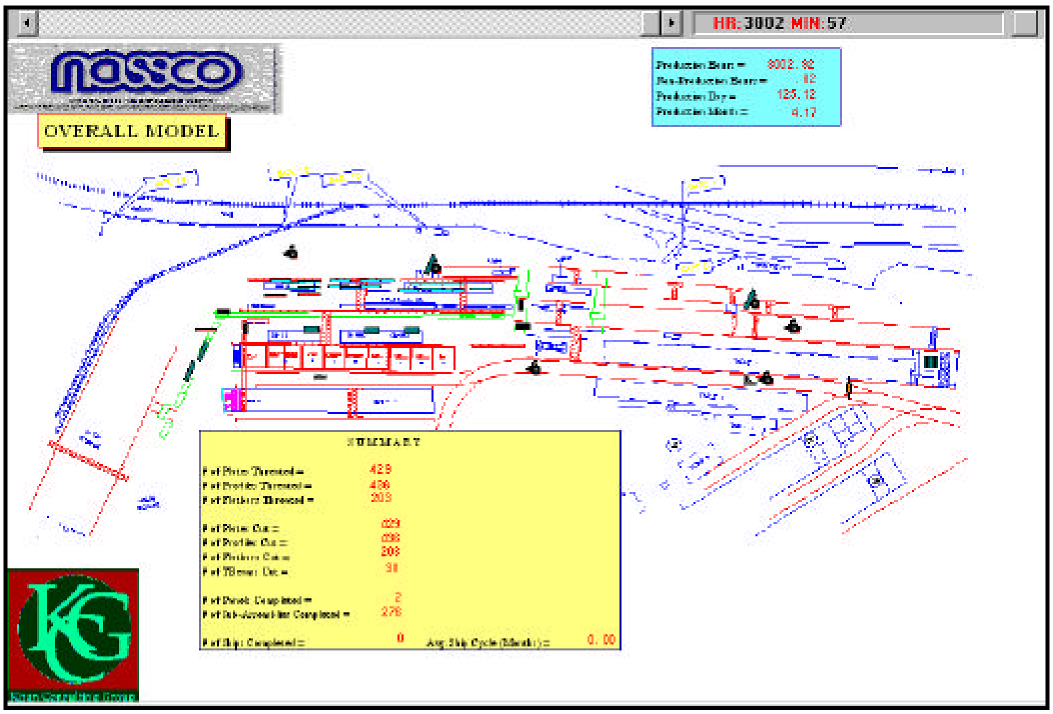

Figure 8

7.0 Results from Overall Model

During the verification of the Overall Model an important process constraint was observed in the Blast and Prime Area. Raw stock material was building up in the Blast and Prime queue. Figure 9 shows an example of this for raw stock profiles.

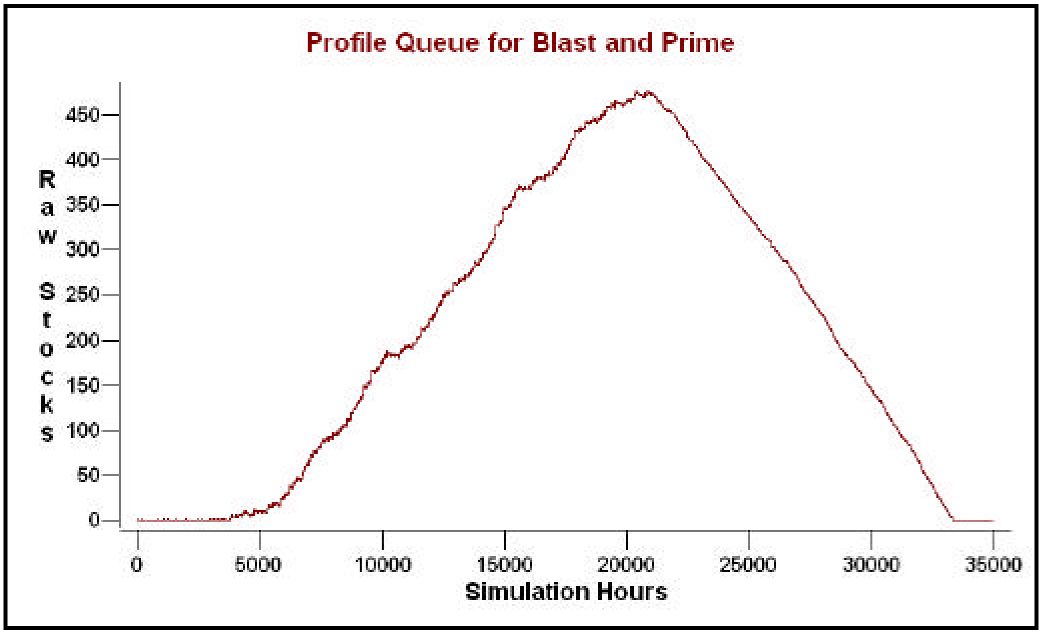

Figure 9

The reason for this is that the Blast and Prime Line is operating at its maximum capacity for almost the entire simulation run (This can be seen in Figure 10.).

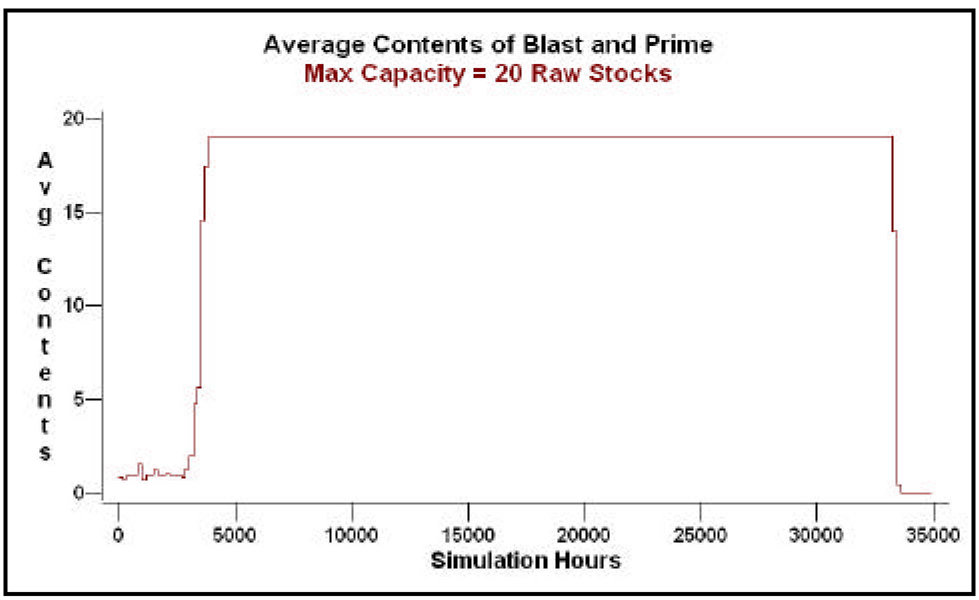

Figure 10

Because the Blast and Prime Line is already a fairly automated operation and there were no major problems apparent in the results of the "As-Is" model of the area, it was not considered a focus area for the introduction of automation. What these graphs show is that although the areas in Fabrication and Subassembly have been optimized individually, when they are operating as a system the Blast and Prime Line does not feed the areas as fast as the they can process the material. In order to take full advantage of the automation that has been optimized in the individual areas, the constraint in the Blast and Prime Area will have to be resolved.

8.0 Next Steps

During the course of this project it was realized that one of the longest duration tasks was assembling the data into a form that could be used by the simulation models. As the use of computer simulation becomes more integrated into the daily business of shipbuilding, the process of creating input data for the models has to be streamlined. Building on the work done in this NSRP project, it was decided that the streamlining of this process would be a major focus of the Ship Factory Transformation II (SFT II) project. Using the Steel Block Assembly Tables as the focus area, a standard method of collecting process data in "macro tasks" was created. This data will be combined with product information from the product modeling system, scheduling information from the scheduling system, and process sequence and flow information from specially created templates. It is envisioned that once the data is created in their native computer applications, the data will automatically be formatted in a way that can be read by the simulation software. Then the models can be used to quickly perform "What-If" scenarios using all of this information. Figure 11 shows the computer system architecture currently planned for the SFT II project.

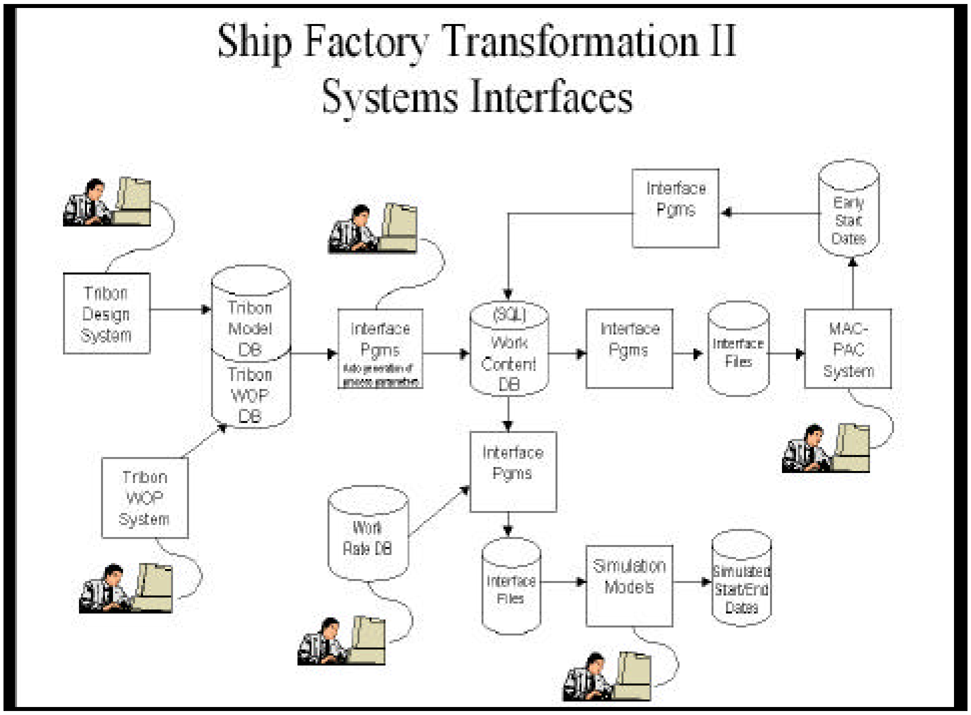

Figure 11

9.0 Conclusions

Significant opportunities for the use of automation exist in the Steel Fabrication and Subassembly areas. Some of the advantages noted during this project include:

- A significant reduction in labor costs
- Better utilization of resources
- Improved material flow
- A positive influence on non-automated factors such as:
  - Variation
  - Accuracy control
  - Manning
  - Safety

The degree to which these factors influence the cost of ship construction, however, is highly dependent upon the yard's facilities, products, and business philosophy. Computer simulation can play a large role in tailoring the automation (or investigating whether automation is even a solution) to the yard's specific requirements in these three areas. The project team felt that computer simulation was particularly important to this project due to its large scope, covering both Steel Fabrication and Subassembly. In addition, computer simulation allows the capability to:

- Analyze variation in product and process
- Analyze changes to a system quickly for
  - Comparisons
  - Optimization
  - Forecasting
  - Scheduling
  - Design

The project team also found that the methodology for producing a simulation model was a perfect catalyst for the discussion and understanding of the manufacturing processes. In order to properly create these models it was necessary to first have a detailed understanding of the system being modeled. Everyone involved in the modeling project had a much greater understanding of the modeled process even before the simulation model was created, and this understanding of the process is extremely valuable to any business regardless of whether or not the simulation itself is used in the decision making process.

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